Research Article

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Effect of dietary inclusion of rice distillers dried grains solubles (RDDGS) with or without enzyme on growth performance and cost economics in broiler chickens

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The present study was carried out to assess the effect of dietary inclusion of rice distillers dried grains solubles (RDDGS) with or without enzyme supplementation on growth performance and cost economics in broiler chickens. A total of two-hundred and forty (240), day-old commercial broiler chicks were randomly allocated into six dietary groups (T_1, T_2, T_3, T_4, T_5 and T_6), each with four replicates of 10 birds. The experimental diets included: T_1 (control diet with conventional feed ingredients), T_2 (control diet with enzyme), T_3 (12.5% RDDGS), T_4 (12.5% RDDGS with enzyme), T_5 (15% RDDGS) and T_6 (15% RDDGS with enzyme). The study was conducted over 42 days, with feed and water provided *ad libitum*. Results revealed that dietary inclusion of RDDGS with enzyme (T_4) significantly ($P<0.01$) improved body weight gain during the starter (530.15 g) and finisher (1717.10 g) phases as well as overall body weight gain (2335.91 g) compared to other treatments. Feed intake was lowest ($P < 0.01$) in birds fed 15% RDDGS, with or without enzyme, whereas feed conversion efficiency was better in birds fed 12.5% RDDGS with enzyme (T_4). Feed cost per kg live weight gain was significantly ($P<0.01$) reduced in T_4 (Rs. 58.44) compared to the control group (Rs. 62.36). Based on the findings, it can be concluded that incorporating 12.5% RDDGS with enzyme supplementation improves growth performance, nutrient utilization and cost efficiency in broiler chickens.

Keywords: Broiler chickens, RDDGS, growth performance, cost economics, protease.

Introduction

The poultry industry is one of the fastest-growing sectors of livestock production, driven by the increasing demand for affordable, high-quality animal protein. However, rising costs of conventional feed ingredients viz., maize and soybean meal pose a major challenge to the profitability of broiler production, necessitating the exploration of cost-effective alternative feed resources.

Distillers dried grains solubles (DDGS) a by-product of the ethanol industry, gained attention as a potential feed ingredient due to its appreciable content of crude protein, energy and digestible amino acids (Fries-Craft and Bobeck, 2019). In India, damaged and surplus grains unsuitable for human consumption are increasingly utilized for ethanol production, enhancing DDGS availability. Among various types, rice distiller dried grains solubles (RDDGS) is abundant in Asian countries due to high rice production, with India producing about 135.76 million tonnes during 2022–23 (Ministry of Fisheries, Animal Husbandry and Dairying, 2023). Rice DDGS is a by-product of ethanol industry, where starch is fermented, leaving behind a nutrient-rich residue containing around 42-50% crude protein along with moderate fiber and fat levels (Singh *et al.,* 2020, Dinani *et al.,* 2022). Despite its nutritional value, the use of RDDGS in broiler diets is limited by non-starch polysaccharides (NSPs) and protein-fibre complexes that reduce nutrient digestibility. Supplementation with protease may improve protein utilization and nutrient availability, thereby enhancing the feeding value of RDDGS. Therefore, the present study evaluated the effect of including RDDGS at 12.5 and 15%, with or without protease, on growth performance and cost economics of broiler chickens.

Materials and Methods

Experimental birds and diets

A total of two hundred and forty (240), day old commercial broiler chicks were randomly (CRD) allocated to six treatment groups (T_1, T_2, T_3, T_4, T_5 and T_6), with four replicates of each containing 10 birds. The experiment was carried out from day-old to 42 days of age in three phases (pre-starter, starter and finisher). Isocaloric and isonitrogenous experimental diets were formulated for broiler pre-starter (0-7 days), starter (08-21 days) and finisher (22-42 days) phases as per the nutrient requirements of broilers (BIS, 2007) shown in Table 1. The basal diet (maize and soybean meal) was control (T_1), while the other experimental diets consists of basal diet with protease enzyme (T_2), 12.5% RDDGS (T_3), 12.5% RDDGS with protease enzyme (T_4), 15% RDDGS (T_5) and 15% RDDGS with protease enzyme (T_6) respectively. The enzyme protease was procured from Kemin Industries South Asia, Pvt. Ltd., Chennai marketed as KEMZYME® PROMACH 5; it was supplemented at a dose of 300 mg/kg. The nutrient composition of the experimental diets is presented in Table 2.

Data collection

The individual body weights of the birds were recorded at weekly intervals up to 6 weeks of age. From this average weekly body weight gain per bird was calculated in all the replica of the six treatments. Feed intake was recorded daily on a replicate-wise basis for each treatment. The feed conversion ratio (FCR) was calculated based on total feed intake and total body weight gain of each replicate. Metabolism trial was conducted during the last five days of the finisher phase, wherein two birds from each replicate (total eight birds per treatment) were randomly selected and housed in metabolic cages equipped with feeding and watering facilities. Birds were fed their respective experimental diets for five

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consecutive days and daily records of feed offered, leftover feed and faeces voided were maintained. Representative faecal samples were pooled over five days and along with feed samples, analyzed for nutrient composition as per AOAC (2019) methods. Nutrient retention (%) of dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and metabolizable energy (ME) was calculated. Cost economics of broilers up to six weeks of age fed RDDGS, with or without enzyme supplementation, was evaluated based on input costs, feed intake and body weight gain. Statistical analysis of the experimental data was performed using one-way ANOVA as described by Snedecor and Cochran (1994) and differences among treatment means were assessed using Duncan's multiple range test (Duncan, 1955) with SPSS Version 21.0 software.

Table 1: Ingredient composition (%) of broiler pre-starter, starter and finisher experimental rations

	Pres-starter						Starter						Finisher					
Ingredients	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
Maize	52.89	52.89	62.79	62.79	63.17	63.17	53.98	53.98	62.54	62.54	63.63	63.63	59.78	59.78	67.87	67.87	65.87	65.87
Soybean meal	40	40	18.71	18.71	15.8	15.8	37.9	37.9	17.7	17.7	13.6	13.6	31.5	31.5	11.6	11.6	11.2	11.2
RDDGS	-	-	12.5	12.5	15	15	-	-	12.5	12.5	15	15	-	-	12.5	12.5	15.0	15.0
Palm oil	2.5	2.5	1.2	1.2	1.0	1.0	3.8	3.8	2.5	2.5	2.75	2.75	4.535	4.535	3.5	3.5	3.5	3.5
Calcite	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.75	1.75	1.9	1.9	1.9	1.9
DCP	1.25	1.25	1.24	1.24	1.2	1.2	1.2	1.2	1.24	1.24	1.2	1.2	1.25	1.25	1.2	1.2	1.1	1.2
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lysine Hcl	0.2	0.2	0.6	0.6	0.67	0.67	0.1	0.1	0.5	0.5	0.6	0.6	0.1	0.1	0.35	0.35	0.35	0.35
DL-Methionine	0.2	0.2	0.1	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Toxin binder*	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Trace mineral**	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vitamin Premix***	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Coccidiostat****	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Liver tonic	0.08	0.08	0.075	0.075	0.075	0.075	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
E care Se	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Phytase	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.01
Protease	-	0.03	-	0.03	-	0.03	-	0.03	-	0.03	-	0.03	-	0.03	-	0.03	-	0.03
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Feed cost/kg diet (Rs.)	37.78	37.79	36.86	36.87	39.35	39.36	37.58	37.59	37.2	37.21	38.21	38.22	36.95	36.96	36.01	36.02	37.27	37.28

Toxin binder (Each kg contains: Phylosilicates :800g, Surfactant: 100 g, Mycotoxin destroyer complex:100g) ** Trace Minerall (Manganese: 54 g, Zinc :52 g, Copper; 4g, Cobalt :0.1 g, Iron :30 g, Chromium :0.2 g, Iodine :1 g and Selenium :100 ppm) * Vitamin premix: (Each kg contains: Vit-A: 50MIU, Vit-D3: 10MIU, Vit-B1: 4g, Vit-B2: 20g, Vit-B6: 6g, Vit-B12: 0.08g, Niacin:48g, Calcium-D pantothenate: 32g, Vit-K3:6g, Vit-E: 20g, Folic acid: 4g) ****Coccidiostat (3-5, Dinitro-O-Toluamide: 25 per cent w/w).*

Table 2: Nutrient composition (% DM) of Pre-starter, starter and finisher experimental diets fed to broiler

	Pres-starter						Starter						Finisher					
Nutrient	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
Dry matter	91.29	91.52	91.42	91.11	91.33	91.07	91.35	90.47	90.57	90.62	91.04	91.32	90.38	90.60	90.08	90.54	90.47	90.81
Organic matter	92.85	92.83	92.89	92.95	92.02	91.75	92.02	91.97	92.78	92.91	92.98	92.84	92.23	92.29	92.27	92.44	92.54	92.60
Crude protein	23.01	23.07	22.98	23.02	22.99	22.96	21.96	22.01	21.91	21.96	22.08	21.92	20.16	20.14	19.94	19.89	19.88	19.91
Ether extract	4.92	4.97	4.49	4.76	4.52	4.51	5.11	5.05	4.95	5.03	4.87	4.85	5.65	5.54	5.17	5.21	4.97	4.95
Crude fiber	4.31	4.33	4.20	4.17	4.26	4.21	4.79	4.76	4.49	4.59	4.48	4.56	5.02	4.99	5.02	5.01	5.12	5.13
Total ash	7.15	7.17	7.11	7.12	7.17	7.05	7.98	8.02	7.21	7.07	7.01	7.15	7.76	7.70	7.72	7.56	7.46	7.40
Acid insoluble ash	1.08	1.06	1.06	1.03	1.05	1.11	1.79	1.76	1.62	1.61	1.56	1.58	1.77	172	1.53	1.58	1.47	1.44
Nitrogen free extract	60.61	60.46	61.22	60.93	61.06	61.27	60.16	60.16	61.44	61.35	61.56	61.52	61.41	61.63	62.15	62.33	62.57	62.61
ME (kcal/kg) *	3006	3010	3013	3019	3020	3014	3100	3100	3100	3098	3097	3100	3200	3200	3203	3198	3199	3200
Calcium	1.02	1.01	1.01	1.02	1.02	1.01	1.01	1.03	0.99	0.97	0.98	0.99	0.98	0.97	0.94	0.93	0.93	0.95
Total phosphorus	0.69	0.68	0.70	0.70	0.72	0.72	0.58	0.58	0.56	0.57	0.60	0.60	0.58	0.60	0.56	0.56	0.60	0.60
Lysine (%) *	1.41	1.41	1.40	1.40	1.43	1.43	1.35	1.35	1.30	1.30	1.31	1.31	1.12	1.12	1.01	1.01	1.10	1.10
Methionine (%) *	0.59	0.59	0.56	0.56	0.79	0.79	0.51	0.51	0.56	0.56	0.77	0.77	0.45	0.45	0.52	0.52	0.74	0.74

*Calculated values

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Table 3: Effect of dietary inclusion of rice distillers dried grains solubles (RDDGS) with or without enzyme on growth performance in broilers

Parameter	Phases	Treatments					
		T1	T2	T3	T4	T5	T6
Body Weight Gain (g)	Pre-starter (0-7 days)	91.65±1.64	100.10±1.83	91.32±2.02	88.67±6.33	84.11±2.42	90.23±5.65
	Starter (8-21 days) **	506.57^{b}±1.12	515.48^{b}±1.25	504.92^{b}±2.79	530.15^{a}±5.22	508.50^{b}±4.17	507.24^{b}±6.03
	Finisher (22-42 days) **	1663.11^{b}±5.67	1664.06^{b}±3.66	1673.97^{b}±8.37	1717.10^{a}±7.45	1611.65^{c}±4.99	1618.55^{c}±3.30
	Overall (0-42 days) **	2261.33^{c}±5.54	2279.63^{b}±3.19	2270.21^{b}±6.38	2335.91^{a}±7.49	2204.25^{d}±3.98	2216.01^{d}±4.03
Feed Intake (g)	Pre-starter (0-7 days)	95.25±0.74	97.41±1.94	100.70±1.88	94.99±5.16	92.81±2.90	99.10±5.34
	Starter (8-21 days) **	705.99±1.30	711.92±4.20	688.53±7.94	701.96±10.15	703.55±3.85	681.38±11.46
	Finisher (22-42 days) **	2936.82^{b}±8.49	2970.86^{a}±7.09	2936.59^{b}±6.69	2977.72^{a}±10.14	2908.48^{c}±8.34	2940.57^{b}±7.38
	Overall (0-42 days) **	3738.05^{b}±8.54	3780.19^{a}±3.48	3725.88^{b}±14.70	3774.67^{a}±17.07	3704.84^{b}±10.16	3721.05^{b}±13.25
Feed Conversion Ratio	Pre-starter (0-7 days) **	1.04^{b}±0.014	0.97^{c}±0.026	1.10^{a}±0.004	1.08^{b}±0.022	1.10^{a}±0.017	1.10^{a}±0.024
	Starter (8-21 days) **	1.39^{a}±0.003	1.38^{a}±0.011	1.36^{a}±0.018	1.32^{c}±0.010	1.38^{a}±0.006	1.34^{b}±0.011
	Finisher (22-42 days) **	1.77^{cd}±0.002	1.79^{b}±0.008	1.75^{d}±0.012	1.73^{e}±0.002	1.80^{ab}±0.003	1.82^{a}±0.006
	Overall (0-42 days) **	1.65^{b}±0.001	1.66^{b}±0.003	1.64^{c}±0.010	1.62^{d}±0.005	1.68^{a}±0.001	1.67^{a}±0.004
Cost Economics	Cost of feed per bird (Rs.)**	141.01^{a}±0.14	139.03^{bc}±0.59	136.45^{d}±0.20	136.51^{d}±0.83	139.83^{ab}±0.19	138.07^{c}±0.26
	Feed cost/kg live weight gain (Rs.)**	62.36^{b}±0.10	60.99^{c}±0.18	60.11^{d}±0.25	58.44^{e}±0.18	63.44^{a}±0.10	62.31^{b}±0.05

^{abcde}Values bearing different superscripts in a same row differ significantly **(P < 0.01).

Feed Intake

Feed intake (Table 3) was highest (P<0.01) in broilers fed 12.5% RDDGS with enzyme (T_4) or control diet with enzyme (T_2), as compared to control diet without enzyme (T_1), 12.5% RDDGS without enzyme (T_3), 15% RDDGS with enzyme (T_6) and 15% RDDGS without enzyme (T_5). The present results are in agreement with the findings of Rao *et al.* (2016) who observed reduction in feed intake when 15% of RDDGS was fed to birds. The results obtained by Dinani *et al.* (2022) are in agreement with the present findings, where feed intake was not significantly affected by RDDGS inclusion at 7.5, 10 and 12.5% with or without enzyme. Kumar *et al.* (2023) noted that higher levels of RDDGS may result in nutrient imbalances, further suppressing feed intake, also the fine texture and powdery nature of RDDGS, coupled with its residual ethanol odor and bitter taste, may have negatively impacted palatability.

Feed Conversion Ratio

The present results (Table 3) indicated feed conversion ratio was better (P < 0.01) in birds fed 12.5% RDDGS with enzyme (T_4) followed by 12.5% RDDGS without enzyme (T_3) or control diet with enzyme (T_2) or control diet without enzyme (T_1) , while lowest in 15% RDDGS either with (T_6) or without enzyme (T_5). The present findings are consistent with Dinani *et al.* (2022), who reported poorer feed conversion efficiency at 15% RDDGS compared to 12.5%, while enzyme supplementation (xylanase, protease and multienzyme) significantly (P<0.01) improved feed conversion ratio. Rao *et al.* (2016) found that including up to 10% RDDGS in broiler diets did not affect feed efficiency, but higher levels (15%) significantly reduced feed conversion ratio. The reduced feed conversion efficiency at higher levels of RDDGS may be due to lower lysine availability (Xue *et al.*, 2012), over estimation of metabolizable energy and reduced bulk density of the diets (Wang *et al.*, 2008)

Nutrient Retention

Incorporation of RDDGS with or without enzyme had no significant effect on DM, OM, EE and CF retention (Table 4). However, CP retention was significantly higher (P<0.01) in enzyme-supplemented groups (T_2, T_4, T_6). Similarly, ME retention differed significantly (P<0.01), being highest in T_4 and T_2, moderate in T_6 and lowest in non-enzyme supplemented groups (T_1, T_3 and T_5). The present results are in agreement with Butle (2024), who reported no significant effect on DM, EE, CF except higher CP metabolizability with protease supplemented RDDGS diets. Similarly, Dinani *et al.* (2022) and Kwak *et al.* (2024) observed improved nitrogen retention and energy metabolizability with enzyme supplementation, irrespective of RDDGS levels.

Table 4: Effect of dietary inclusion of rice distillers dried grains solubles (RDDGS) with or without enzyme on nutrient retention (%) in broilers

Treatments	Parameter (%)					
	T1	T2	T3	T4	T5	T6
DM	71.60±0.56	72.59±0.97	71.42±0.77	73.27±0.44	70.68±059	71.18±0.47
OM	76.31±0.41	77.18±0.96	76.44±0.64	77.42±0.49	75.62±0.54	76.06±0.63
CP **	67.57^{c}±0.63	74.80^{a}±0.90	68.01^{c}±0.84	75.77^{a}±0.41	66.57^{c}±0.74	71.44^{b}±0.37
EE	78.36±0.64	77.80±0.93	76.97±0.62	77.39±0.63	76.02±0.39	76.14±0.38
CF	25.26±0.54	27.71±1.95	26.59±0.46	27.94±0.39	26.75±1.25	26.90±0.71
ME**	74.61^{c}±0.37	77.54^{a}±0.23	74.47^{c}±0.50	78.19^{a}±0.44	73.88^{c}±0.65	76.65^{b}±0.49

^{abc}Values bearing different superscripts in a same row differ significantly **(P < 0.01). DM=Dry Matter; OM=Organic Matter; CP=Crude Protein; EE=Ether Extract; CF=Crude Fiber; ME=Metabolizable Energy.

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Cost Economics

The feed cost per kg live weight gain (Table 1) ranged from Rs. 58.44 (T_4) to Rs. 63.44 (T_5). Broilers fed diets containing 12.5% RDDGS with enzyme (Rs.58.44 in T_4) had significantly ($P < 0.01$) lower feed cost per kg live weight gain, followed by 12.5% RDDGS without enzyme (Rs.60.11 in T_3), control diet with enzyme (60.99 in T_2), 15% RDDGS with enzyme (62.31 in T_6) or control diet (62.36 in T_1), while the highest cost was recorded in 15% RDDGS without enzyme (63.44 in T_5). Feed cost per kg live weight gain decreased by Rs. 0.88 and 2.35 in 12.5% RDDGS diets (with or without enzyme), while it increased by Rs. 2.45 and 1.32 in 15% RDDGS diets compared to control (T_1). These findings agree with Dinani *et al.* (2022), Gupta *et al.* (2019) and Khose *et al.* (2021), who also reported improved cost efficiency with RDDGS and enzyme supplementation. Based on the findings, it can be concluded that incorporating 12.5% RDDGS with enzyme supplementation improves growth performance, nutrient utilization and cost efficiency in broiler chickens.

Conclusion

Rice DDGS can be effectively used as a feed ingredient in broiler diets up to an inclusion level of 12.5% with enzyme supplementation without negatively affecting growth performance and nutrient utilization; however, increasing the inclusion level to 15% resulted in poor performance either with or without protease enzyme.

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